

LISTING OF THE CLAIMS

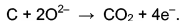
1. (original) A direct-electrochemical-oxidation fuel cell for generating electrical energy from a solid-state organic fuel comprising:

a cathode provided with an electrochemical-reduction catalyst that promotes formation of oxygen ions from an oxygen-containing source at the cathode;

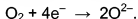
an anode provided with an electrochemical-oxidation catalyst that promotes direct electrochemical oxidation of the solid-state organic fuel in the presence of the oxygen ions to produce electrical energy; and

a solid-oxide electrolyte disposed to transmit the oxygen ions from the cathode to the anode,

wherein direct electrochemical oxidation at the anode occurs according to the reaction:



2. (original) The fuel cell according to claim 1, wherein formation of the oxygen ions at the cathode proceeds according to the reaction:



3. (original) The fuel cell according to claim 1, wherein the solid-state organic fuel is coal, graphite, biomass or a combination thereof.

4. (original) The fuel cell according to claim 3, wherein the biomass is selected from a group consisting of peat, rice hulls, and corn husks.

5. (original) The fuel cell according to claim 1, wherein the direct electrochemical oxidation at said anode produces a product comprising a CO_2 concentration of at least 50 mol %.

6. (original) The fuel cell according to claim 1, wherein the electrochemical-reduction catalyst is lanthanum strontium manganese oxide.

7. (currently amended) The fuel cell according to claim 1, wherein the electrochemical-reduction catalyst is selected from ~~the group consisting of LSF; LSCF; SSC;~~ $\text{La}_{0.8}\text{Sr}_{0.2}\text{FeO}_3$ (LSF); $\text{La}_{0.6}\text{Sr}_{0.4}\text{Fe}_{0.8}\text{Co}_{0.2}\text{O}_3$ (LSCF); $\text{Sm}_{0.5}\text{Sr}_{0.5}\text{CoO}_3$ (SSC); $\text{YBa}_2\text{Cu}_3\text{O}_y$, wherein y is an integer having values within a range of ~~7-9~~ 7 to 9; $\text{La}_{0.99}\text{MnO}_3$; LaMnO_3 ; $\text{La}_x\text{Sr}_y\text{Mn}_3$ and $\text{La}_x\text{Ca}_y\text{MnO}_3$, wherein x is a number having values within a range of ~~0.6-0.95~~ 0.6 to 0.95, and y is a number having values within a range of ~~0.1-0.4~~ 0.1 to 0.4.

8. (currently amended) The fuel cell according to claim 1, wherein the electrochemical-reduction catalyst is selected from ~~the group consisting of a~~ material having a general formula of $\text{A}_x\text{B}_y\text{CO}_3$, wherein A is selected from ~~the group consisting of~~ La, Gd, Sm, Nd, Pr, Tb and Sr, B is selected from ~~the group consisting of~~ Sr, Ce, and Co, x is a number having values within a range of ~~0.6-0.94~~ 0.6 to 0.94, and y is a number having values within a range of ~~0.1-0.4~~ 0.1 to 0.4.

9. (original) The fuel cell according to claim 1, wherein the electrochemical-oxidation catalyst provided to the anode includes platinum.

10. (currently amended) The fuel cell according to claim 1, wherein the electrochemical-oxidation catalyst includes ~~Rhenium~~ rhenium.

11. (original) The fuel cell according to claim 10, wherein the electrochemical-oxidation catalyst is Re-NiO/YSZ.

12. (original) The fuel cell according to claim 10, wherein the electrochemical-oxidation catalyst is Cu oxide-Pt.

13. (currently amended) The fuel cell according to claim 1, wherein the solid-oxide electrolyte is selected from the group consisting of doped oxides of Bi, Zr, Hf, Th, and Ce with either alkaline earth oxides such as CaO or MgO, or rare-earth oxides such as selected from Sc_2O_3 , Y_2O_3 , and Yb_2O_3 , and the like. For example, embodiments of the present invention include a solid-oxide electrolyte 18 comprising at least one of Bi_2O_{27} , $(\text{Bi}_2\text{O}_7)_{0.75}(\text{Y}_2\text{O}_3)_{0.25}$, $\text{BaTh}_{0.9}\text{Gd}_{0.1}\text{O}_3$, $\text{La}_{0.8}\text{Sr}_{0.2}\text{Ga}_{0.8}\text{Mg}_{0.2}\text{O}_{37}$, $(\text{Ce}_2)_{0.8}(\text{GdO}_{0.6})_{0.27}$, $(\text{ZrO}_2)_{0.9}(\text{Se}_2\text{O}_3)_{0.17}$, $(\text{ZrO}_2)_{0.9}(\text{Y}_2\text{O}_3)_{0.17}$, $(\text{ZrO}_2)_{0.87}(\text{CaO})_{0.13}$, $(\text{La}_2\text{O}_3)_{0.95}(\text{SrO})_{0.05}$.

14. (original) The fuel cell according to claim 1, wherein the solid-oxide electrolyte is selected from the group consisting of yttrium-stabilized zirconium and bismuth oxide.

15. (original) The fuel cell according to claim 1, further comprising a housing that encloses the anode for receiving the solid-state organic fuel.

16. (original) The fuel cell according to claim 15, further comprising feed passage through which the solid-state organic fuel can be inserted into the housing.

17. (original) The fuel cell according to claim 1, wherein the electrochemical oxidation that occurs at the anode produces a product comprising a NO_x concentration of less than 5 mol %, wherein x is an integer within a range of 1 to 3.

18. (original) The fuel cell according to claim 17, wherein the fuel cell has a maximum operating temperature of about 1200°C.

19. (original) The fuel cell according to claim 1, wherein the direct electrochemical oxidation that occurs at the cathode results in a product comprising a CO concentration that is less than 10 mol %.

20. (original) The fuel cell according to claim 19, wherein the fuel cell has a maximum operating temperature of about 1200°C.

21. (original) The fuel cell according to claim 1, wherein the fuel cell produces an electrical current of at least 100 mA/cm² for a period of time lasting at least 48 hours.

22. (original) The fuel cell according to claim 1, wherein the fuel-conversion efficiency of the fuel cell is at least 30 mol % at 950°C.

23. (original) A direct-electrochemical-electrochemical oxidation fuel cell for generating electrical energy from a solid-state organic fuel comprising:

a cathode provided with an electrochemical-reduction catalyst that promotes the formation of ions from an ion source at the cathode;

a anode provided with an electrochemical-oxidation catalyst that includes a sulfur-resistant material and promotes electrochemical oxidation of the solid-state organic fuel in the presence of the ions formed at the cathode to produce electrical energy; and

a solid-oxide electrolyte disposed to transmit the ions from the cathode to the anode.

24. (original) The fuel cell according to claim 23, wherein the sulfur-resistant material includes at least one of Re, Mn and Mo.

25. (currently amended) The fuel cell according to claim 24, wherein the sulfur-resistant material is selected from ~~the group consisting of Re-NiO/YSZ and~~ Cu oxide-Pt.

26. (original) The fuel cell according to claim 23, wherein the electrochemical-reduction catalyst is lanthanum strontium manganese oxide.

27. (currently amended) The fuel cell according to claim 23, wherein the electrochemical-reduction catalyst is selected from ~~the group consisting of LSF; LSCF; SSC;~~ $\text{La}_{0.8}\text{Sr}_{0.2}\text{FeO}_3$ (LSF); $\text{La}_{0.6}\text{Sr}_{0.4}\text{Fe}_{0.8}\text{Co}_{0.2}\text{O}_3$ (LSCF); $\text{Sm}_{0.5}\text{Sr}_{0.5}\text{CoO}_3$ (SSC); $\text{YBa}_2\text{Cu}_3\text{O}_y$, wherein y is an integer having values within a range of ~~7-9~~ 7 to 9; $\text{La}_{0.99}\text{MnO}_3$; LaMnO_3 ; $\text{La}_x\text{Sr}_y\text{Mn}_3$ and $\text{La}_x\text{Ca}_y\text{MnO}_3$, wherein x is a number having values within a range of ~~0.6-0.95~~ 0.6 to 0.95, and y is a number having values within a range of ~~0.1-0.4~~ 0.1 to 0.4.

28. (original) The fuel cell according to claim 23, wherein the ions formed at the cathode are oxygen ions formed according to the reaction:



29. (original) The fuel cell according to claim 23, wherein the solid-state organic fuel is coal, graphite, biomass, polymers or a combination thereof.

30. (currently amended) The fuel cell according to claim 29, wherein the biomass is selected from ~~a group consisting of~~ peat, rice hulls, and corn husks.

31. (currently amended) The fuel cell according to claim 23, wherein the solid-oxide electrolyte is selected from ~~the group consisting of doped oxides of Bi, Zr, Hf, Th, and Ce with either alkaline earth oxides such as CaO or MgO, or rare-earth oxides such as selected from~~ Sc_2O_3 , Y_2O_3 , and Yb_2O_3 , ~~and the like. For example, embodiments of the present invention include a solid oxide electrolyte comprising at least one of~~ Bi_2O_3 , $(\text{Bi}_2\text{O}_3)_{0.75}(\text{Y}_2\text{O}_3)_{0.25}$, $\text{BaTh}_{0.9}\text{Gd}_{0.1}\text{O}_3$, $\text{La}_{0.8}\text{Sr}_{0.2}\text{Ga}_{0.8}\text{Mg}_{0.2}\text{O}_3$, $(\text{Ce}_2)_{0.6}(\text{GdO}_{0.5})_{0.27}(\text{ZrO}_2)_{0.9}(\text{Sc}_2\text{O}_3)_{0.47}$, $(\text{ZrO}_2)_{0.9}(\text{Y}_2\text{O}_3)_{0.47}$, $(\text{ZrO}_2)_{0.87}(\text{CaO})_{0.13}$, $(\text{La}_2\text{O}_3)_{0.95}(\text{SrO})_{0.05}$.

32. (original) The fuel cell according to claim 31, wherein the solid-oxide electrolyte is selected from the group consisting of yttrium-stabilized zirconium and bismuth oxide.

33. (original) The fuel cell according to claim 23, wherein electrochemical oxidation of the solid-state organic fuel at the anode produces a product having a CO₂ concentration of at least 50 mol %.

34. (original) The fuel cell according to claim 33, wherein the fuel cell has a maximum operating temperature that is less than 1200°C.

35. (original) The fuel cell according to claim 23, wherein electrochemical oxidation of the solid-state organic fuel at the anode produces a product having a NO_x concentration that is less than 0.1 mol %, wherein x represents integers ranging from 1 to 3.

36. (currently amended) The fuel cell according to claim 23, wherein the electrochemical-oxidation catalyst is selected from the group consisting of a noble metal, group VIII metal/metal oxide, ~~such as Pt, Cu, Ag, Au, Pd, Ni,~~ oxides of the ~~aforementioned~~ sulfur-resistant materials, oxides of Ce, Cr, Fe, and Pb, combinations thereof, multiple oxides, ~~combinations including one or more of the aforementioned metals,~~ Cu oxide-Pt, and Re-NiO/YSZ, wherein the electrochemical-oxidation catalysts including non-noble metals also include a sulfur-resistant substance selected from ~~the group consisting of~~ Re, Mn, Mo, Ag, Cu, and Au.

Claims 37 through 40, cancelled.

41. (new) The fuel cell according to claim 13, wherein the solid oxide electrolyte comprises at least one of Bi₂O₂, (Bi₂O₇)_{0.75}(Y₂O₃)_{0.25}, BaTh_{0.9}Gd_{0.1}O₃, La_{0.8}Sr_{0.2}Ga_{0.8}Mg_{0.2}O₃, (Ce₂)_{0.8}(GdO_{0.5})_{0.2}, (ZrO₂)_{0.9}(Sc₂O₃)_{0.1}, (ZrO₂)_{0.9}(Y₂O₃)_{0.1}, (ZrO₂)_{0.87}(CaO)_{0.13}, (La₂O₃)_{0.95}(SrO)_{0.05}.

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42. (new) The fuel cell according to claim 31, wherein the solid oxide electrolyte comprises at least one of Bi_2O_3 , $(\text{Bi}_2\text{O}_7)_{0.75}(\text{Y}_2\text{O}_3)_{0.25}$, $\text{BaTh}_{0.9}\text{Gd}_{0.1}\text{O}_3$, $\text{La}_{0.8}\text{Sr}_{0.2}\text{Ga}_{0.8}\text{Mg}_{0.2}\text{O}_3$, $(\text{Ce}_2)_{0.8}(\text{GdO}_{0.5})_{0.2}$, $(\text{ZrO}_2)_{0.9}(\text{Sc}_2\text{O}_3)_{0.1}$, $(\text{ZrO}_2)_{0.9}(\text{Y}_2\text{O}_3)_{0.1}$, $(\text{ZrO}_2)_{0.87}(\text{CaO})_{0.13}$, $(\text{La}_2\text{O}_3)_{0.95}(\text{SrO})_{0.05}$.